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RESEARCH AND DEVELOPMENT IN THE
PETROCHEMICAL INDUSTRY IN DEVELOPING COUNTRIES

Issue Paper*

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I. BACKGROUND

1. Research and development (R and D), although discussed in various contexts with other questions, has not been raised as a separate issue in previous Consultations on the petrochemical industry. It has been mentioned, inter alia, in the framework of long-term arrangements in the petrochemical industry ^{1/} when dealing with access to technology and to its improvements.
2. The joint OPEC/UNIDO/OPEC-Fund Seminar on Co-operation Among Developing Countries in Petrochemical Industries in March 1983, recommended that UNIDO should actively promote co-operation among the developing countries' R & D centres by facilitating their contacts and exchange of experience. It also considered that viable co-operation agreements could be based, inter alia, on obtaining regional skills to design and construct petrochemical plants which otherwise might not be forthcoming in view of prohibitive costs. At a second stage the objective would be to attain R & D capabilities to develop autonomous technology ^{2/}.
3. The First Meeting of the Advisory Panel on Petrochemicals of October 1983 discussed briefly research and development in petrochemicals and concluded that this field represents an essentially uncharted territory for most developing countries. It also regretted that in-house R and D of purchased technology, including after sales services are often subject to secrecy clauses as part of the transfer agreements ^{3/}.
4. The Second and Third Meetings of the Advisory Panel on Petrochemicals held in September 1984, and June 1985 respectively, generally examined this subject again. These meetings expressed concern at the inadequacies of applied research and development capabilities in developing countries without which the long-term operational viability of the petrochemical industries in these countries could not be ensured ^{4/}.

^{1/} (ID.WG.336/7/Rev.1. Paras.40,43)

^{2/} Report on OPEC/UNIDO/OPEC-FUND Seminar on Co-operation
Among Developing Countries in Petrochemical Industries

^{3/} UNIDO/PC. 82

^{4/} Reports on Second and Third Meeting of Advisory Panel on
Petrochemicals

5) The Meeting on Co-operation among the developing countries of the Middle Eastern and North African Regions in the Petrochemical Industries held in Aliaga, Turkey, in October 1984, also discussed the R & D activities in some of the regional countries. It inter-alia recommended the holding of a special meeting of R and D in the petrochemical industry.^{5/}.

^{5/} Report on Meeting on Co-operation among the Developing Countries of the Middle Eastern and North African Region in the Petrochemical Industry, Aliaga, Turkey, October 1984.

II. INTRODUCTION

6. The value of world chemical consumption will approach 900,000 million US Dollars in 1985 with petrochemicals accounting for more than half of that figure ^{6/}. The petrochemical sector has persistently outperformed the aggregate rate of output of most national economies. For instance the industry's track-record of some 9% growth in 1984 and the continued expansion in the current year, expected to reach 4-5%, contrasts vividly with considerably weaker performance in the global economy in the same period.

7. More significantly, this achievement is set against a background of weighty forces which had detrimentally affected the industry's operational environment in the preceeding decade:

- 1) a six-fold escalation in the procurement costs of energy and feedstock for commodity chemical production
- 2) substantially higher pollution control expenditures as a result of environmental legislation which, in the case of the United States, for example, had doubled the costs in real terms
- 3) near-saturation of the dominant market segments of bulk chemicals and stagnating end-use demand for basic chemical products
- 4) maturing of the main process technologies

8. It is widely recognized that the key factor, responsible for the petrochemical industry's remarkable resilience and adaptability to changed circumstances is technology and its prerequisite research and development. R & D expenditures in the chemical industries of USA and FRG in relation to total capital outlays are given in table 1.

^{6/} Chemical Economy and Engineering Review, December 1984

Table 1

Expenditures in billion US \$ (current)

	1975	1980	1981	1982	1983	1984	1985*
USA							
R and D expenditures	1.1	2.0	2.3	2.6	2.8	3.1	3.4
Capital expenditures	5.0	7.2	7.3	6.4	5.1	5.4	6.1
R and D/Capital (%)	22	28	32	41	55	57	56
FRD							
R and D expenditures	0.6	1.6	1.75	1.9	2.0	2.2	n.a.
Capital expenditures	1.8	2.2	2.35	2.3	2.3	2.3	n.a.
R&D/capital (%)	33	73	74	83	87	98	n.a.

* planned

Source: Chemical Week, June 1985,
Chemical and Engineering News, June 1985.

9. The massive R & D expenditures of recent years are coming increasingly into fruition. The resulting technological advances have already spearheaded the renewed vigour and restored the profitability of the petrochemical industry by enabling:

- 1) close control of costs, notably through energy savings;
- 2) innovation on conventional products and processes;
- 3) development of new product applications and
- 4) upgrading production efficiency and productivity

10. The shift from the high-volume primary petrochemicals, ethylene, propylene, aromatics and their first-line derivatives, to higher value-added specialty and functional products is the direct expression of capitalizing on the technological edge enjoyed by research-based producers.

11. In a nutshell analysis the current technological transition is essentially characterized by two-pronged progress made in enhancing the capability of a given process in respect to technical product range and to the supply potential for various grades of products.

12. Interestingly the move to high technologies, and the resultant fragmentation and specialization, has also brought about a refocussing of many corporate strategies from the purely manufacturing to a growing service orientation. This stems from the "total product" concept where higher value-added components based on research and development potential are to augment the basic manufacturing in the form of broadly defined customer services. An inevitable consequence of the current search for enhanced commercialization of technology is causing a reduction in the traditional dominance of national or regional outlook in favour of a more global framework for strategic planning. In any event this process of geographic integration has already been set in motion by the concurrent quest for advantageously priced feedstocks together with immature and expanding markets.

III. ORGANIZATION OF RESEARCH AND DEVELOPMENT

13. The research and development efforts can be divided into four categories as defined below:

- (1) basic research
- (2) process know-how
- (3) product know-how
- (4) technical improvements.

14. Often, research which is applied to the equipment and other facilities or on product application or improvements after the technology has been deployed is called generically applied research. The research and development contains many components especially when specifics are discussed. For the above reasons, UNIDO Secretariat has intended to open an issue of a general nature, under an umbrella-definition, which should cover all future efforts in this field whatever forms they might take, rather than to take narrowly defined concepts and formulations.

15. Basic research which has often been called pure or fundamental research, studies mainly the nature of chemicals and their reactivity, the properties of elements, chemical processes and the hybrid compounds that can be induced. This research is usually carried out in universities and technical institutions or in specialized research laboratories. However larger chemical or oil companies can afford to maintain their own facilities.

16. Many companies do not consider it expedient to spend resources on pure research because of insecure or low returns on invested capital. Customarily the chemical companies spend relatively small portions of their overall R & D fundings on basic research and often sponsor and co-operate with academia and research institutions. However, recently it has become evident that the technologies used are in many instances outmoded, energy wasting, environmentally polluting and not sufficiently quality conscious. Principally, everything which was considered unalterable and inevitable in established technologies has become a candidate for major scrutiny and improvements, including equipment, utilities, catalysts, conventional reactions, materials etc. The results of this development are new processes, products and technologies. In fact, it has become a necessity, in global competition for market shares in the petrochemical industry, to create a R & D competitive edge in basic research to support other R & D functions.

17. Process research and development is a major R & D activity of chemical companies which concentrate their efforts on designing new and better processes with significantly lower costs and improved quality of products. A good example of this are the UNIPOL polyethylene and polypropylene processes based on fluidized-bed technology.

18. In many end product applications, the process itself does not necessarily play the most important role, but competitiveness depends rather on factors such as product formulation and product systems based on a particular technology or raw materials composition.

The objective is to build up a unique system incorporating innovative technologies to yield quality properties in response to very specific consumer requirements. A good example of such a product system is the creation of large high density polyethylene pipes which are extruded from high density polyethylene, freely available from different sources. The system embraces not only pipes, but also fittings, welding technology etc. Companies which utilize this type of R & D are often medium or small-sized. They therefore need back-up from specialized R & D institutions, government offices etc.

19. Technical improvements are widely used in the process industries as routine tools to improve the process, to make it safer, to control emissions, to reduce costs, to improve catalyst systems, separation facilities etc... All physical facilities and utility systems are involved in the effort to keep the products competitive in the market place. Traditionally stable and uneventful, this field has become dynamic since the seventies. Now, it often leads to the creation of patented innovations like HIGEE-distillation system, new separation processes as part of any commercial process plant. The number of unpatented improvements is unaccounted for, involving alterations to principally all equipment. The area of technical improvements can be considered as an important part of technology with immediate relevance to operating petrochemical complexes in the developing countries.

IV. OWNERSHIP-STRUCTURE AND DEVELOPMENT PATTERN OF PETROCHEMICAL TECHNOLOGY

20. The present stock of hydrocarbon technologies is concentrated in private, and to a lesser extent public, corporations of few industrialized market economies, notably United States, United Kingdom and Federal Republic of Germany with some inroads made recently by other countries. The technological orientation of the industry until the mid-seventies period was largely conditioned and influenced by:

- 1) availability of products of the petroleum refining and energy industries such as naphtha in Europe and natural gas in the United States;
- 2) penetration of resource-rich oil companies into first generation petrochemical derivatives, contrasted with little corresponding "backward integration" of chemical corporations;
- 3) technological diversification due to geographical variations in market forces and sectoral compositions;
- 4) large potential for substitution of traditional materials by thermoplastics, synthetic fibres and elastomers;
- 5) pre-dominance of engineering companies as technological innovators particularly in intermediates and upstream technologies;
- 6) geographic concentration of the industry in the immediate vicinity of main markets with a virtual absence of production sites at supply sources of raw materials; and
- 7) no significant dispersion in the established ownership pattern of the industry.

21. The quadrupling of oil prices in 1973/74 had far-reaching consequences on the conduct of business of the chemical corporations. The accompanied technological implications were further accentuated by the second upsurge in energy and feedstock costs in 1979. The necessary reassessment of corporate priorities to adapt to and survive in a changed environment have, inter-alia, contributed to:

- 1) increased efforts of chemical companies for up-stream integration through mergers and acquisitions, particularly in the United States;
- 2) search for alternative feedstocks technology such as heavy residue-derived syngas for chemicals and biomass technology;
- 3) greater built-in flexibility for feedstock variations;
- 4) enhanced participation of the state directly or through the public sector in reshaping the industry, particularly in Europe and Japan;
- 5) further international diversification of production and marketing;
- 6) major additional R & D expenditures with a view to increasing energy and raw material efficiencies of conventional materials and processes;
- 7) rationalization in bulk commodities and incipient emergence of performance products in composites, engineering plastics, etc.;
- 8) a two-fold expansion of corporate basic R & D budgets leading to technological breakthroughs especially in surface chemistry and catalysts with high selectivity, which enable scaling down of plant size;
- 9) proliferation of multiple and competing technologies, particularly for the manufacture of intermediates;
- 10) emphasis on multi-disciplinary R & D with some bias towards physics and biology, rather than pure chemistry;
- 11) accelerated rate of technological obsolescence;
- 12) closer synchronization between market intelligence and technology response;
- 13) technological diversification through the dual approach of increased R&D fundings and technology acquisition; and
- 14) certain entrenchment against market penetration in commodities by new producers.

REORIENTATION OF CORPORATE RESEARCH AND DEVELOPMENT STRATEGIES
IN THE CHEMICAL INDUSTRY

22. R & D corporate strategy, although wide disparities between individual firms persist, is undergoing a significant transition. The centre piece of change, invariably, involves a closer integration between research, manufacturing and marketing functions of the company. In this context an obvious distinction should be made in the segmentation of R and D efforts in the petrochemical industry. The upstream-industries concentrate in process research which requires strong support from basic and fundamental knowledge in chemistry and engineering whereas downstream-operations rely heavily on applied research and technical services. The traditional approach of "product orientation" where first the creation of a product was initiated through R & D and subsequently attempts were made to market it, have all but been phased out. The new approach consists of developing product lines in response to well-identified and specific needs of the customer. Therefore in many petrochemical companies there has been an emerging shift of emphasis from "process R & D" to "product R & D" which, in turn, translates into larger expenditures on technical services. The nature of process R & D itself has undergone qualitative mutations to find simpler and cheaper routes with less resource consuming facilities. An important consequence of this reorientation in policy can be gauged from the corporate R & D budget distribution by product segment which clearly reflects the progressive move to higher value-added and technologically sophisticated products, particularly industrial specialities. R & D figures for a major chemical company, contained in table 2 clearly demonstrates the trend.

Table 2

R & D funds distribution within a typical chemical company
(per cent)

<u>By product segment</u>	1982	1983	1984
Industrial specialities	31	33	40
Consumer specialities	32	34	33
Basic chemicals	23	29	18
Basic plastics	8	8	8
Other	6	5	1
<u>by R & D category</u>			
Product research	40	44	44
Process research	29	23	22
Technical service and development	31	33	34

Source: Chemical and Engineering News, March 1985.

23. The priority areas absorbing the bulk of current R & D fundings are molecular and biotechnology, composites, ceramics and spaciality resins. The trend towards new products would conceivably be even more pronounced but for some inertia of traditional business commitments of the major companies in process technologies and geographical expansion of their bulk operations.

24. The prerequisite for devising new application fields and products calls for detailed, comprehensive and essentially new breed's of market intelligence through modern techniques. The innovative technical sale and distribution networks are designed for providing total integrated services. The search for novel uses of existing products and the development of new ones is characteristically conducted through direct and close contact with the customer, which has necessitated a thorough revision of the training requirements and the technical skills of the marketing and sales force.

25. Another aspect of the diversification into new markets and products is manifest through aggressive aquisition of technology, particularly, when synergistic with the ongoing operations of the company. The trend of technology purchase, as opposed to less certain and more time consuming R & D path, for strengthening competitive positions will further accelerate as resource-rich countries increase their penetration of commodity markets. This is quite consistant with emerging evidence of some decentralization of product adaptive R & D and a burgeoning interest for foreign scientific communities and establishments within the practical limits imposed on affiliate R & D by the exigencies of the critical mass or minimum efficient scale, inherent to the chemical industry. In the main industrialized countries a major share of the basic chemical research is performed at academic institutions. However, in recent years, the fluctuations in the level of public support and funding uncertainties have caused some discontinuity in institutional research programmes.

VI. THE RELEVANCE OF THIRD WORLD'S AUTONOMOUS TECHNOLOGY
IN PETROCHEMICALS

26. The production possibilities of ethylene, the primary petrochemical building block, can illustrate the option of alternative technologies in response to feedstock availability and other technical factors. For example in the United States, ethylene is mainly produced from natural gas whereas in Europe it is mostly naphtha based. Furthermore, in spite of ethylene's gaseous nature, its suitability to maritime and pipeline transport has greatly improved recently due to technology. As a consequence, the bulk of international trade in this commodity is no longer confined to neighbouring countries as it was during the seventies. Nevertheless most producers of ethylene convert it into derivatives on site in preference to its shipment as a petrochemical intermediate.

27. The economies of scale, dictated by the conventional technologies in plant size also plays a critical role in the investment decision of new capacities. To construct an economically efficient ethylene process, must therefore take into account many considerations specific to the locational characteristics of raw material, infrastructure, marketing channels and so on.

28. World production of ethylene in 1984 was in the order of some 38 million tons with naphtha accounting for 54%, ethane for 22%, LPG for 15%, gasoil and others for 9% of the feedstock requirements. A structural shift in the international pattern of ethylene supplies is currently underway as a result of incipient exports of ethylene and its derivatives from the new petrochemical producing areas such as Saudi Arabia and Canada. Globally, the use of ethane as feedstock for ethylene manufacturing is expected to increase to around 30% over the next decade, a trend set essentially by economics. However, for countries possessing abundant fermentation materials but limited hydrocarbon resources such as Turkey, India, Pakistan and a number of Latin American countries, technologies using those alternative feedstocks have obvious economic and social significance. In 1975 Brazil embarked upon an ambitious R & D effort, in the framework of the "Proalcool" programme, in both the utilization and production technologies of alcohol fuels and other alternative energy sources. It still constitutes the largest operational alternative fuels programme in the world. Currently some 130.000 b/d of ethanol are thus produced in the country. Based on the availability of this

ethanol, Petrobrás, the national oil company, has developed a process, at its research centre Cenpés, for the conversion of ethanol to ethylene. The adiabatic process, in contrast to the conventional isothermic units, has a high conversion rate of around 99%. More significantly, in view of the reduction in the number of reactor vessels to three (in comparison with the required eight in isothermal reaction system) the capital expenditure of a production facility amounts to a mere fraction of the conventional unit.

29. The Cenpés process, conveniently incorporates other advantageous features, apart from the crucially important capital costs and feedstock. Among these, simplicity and flexibility of operation, infrequent catalyst regeneration, greater purity and selectivity are particularly relevant to operational environment of the developing countries. The first operating plant, using this technology, is currently producing 90.000 metric ton annually of ethylene.

30. The Brazilian ethylene process is indicative of the feasibility of selective and rational technological response to the condition prevailing in the developing countries through R & D.

31. Expectedly this technology has provoked considerable interest outside Brazil, most notably among the developing countries, in view of its obvious merits. Negotiations are currently underway for the licensing of the technology to a number of developing countries among them Philippines, Indonesia, Peru, Kenya etc. India is reported to have already acquired the process know-how for a 5000 t/y preliminary project currently underway. Although the emergence of this particular technology will not affect the global picture of the ethylene business as described above to any significant extent, its repercussions on the viability of individual projects to manufacture ethylene dichloride and other derivatives with indigenous feedstocks in many developing countries could be decisive.

VII. PETROCHEMICAL TECHNOLOGIES IN USE IN DEVELOPING COUNTRIES
AND THEIR DRAW-BACKS

32. The establishment of petrochemical complexes in the developing countries has customarily posed serious challenges. The various aspects of the obstacles at play, have been and continue to be closely investigated by industry analysts and international fora including UNIDO's System of Consultations. Problems associated with contextual definition of projects, infrastructural and resource limitations, transfer of technology, marketing and management, technical operation and maintenance, education and manpower training, international co-operation etc., have, rightfully, assumed wide-scale recognition and are subjected to expert scrutiny.

33. Nevertheless, it must be reemphasized that the spectacular growth of the petrochemical industry in the post-war period has been, to a large extent, due to technological breakthroughs in the production of synthetic materials. This was followed by the emergence of processing technologies for the transformation of those derivatives into a multitude of products, particularly for use in such sectors as agriculture, construction, textiles, industrial and, most importantly, consumer goods. These technologies were entirely developed in the industrialized countries through a concerted pattern of research and development strategy based, inter alia, on the resource and feedstock availabilities and prevalent market characteristics. A major illustrative example, in this context, was the access, in Europe during fifties and sixties, to competitively priced naphtha as a refinery by-product which prompted the emergence of technological innovations in synthetics. Similarly, in the wake of price escalations of feedstock and energy in the seventies, the bulk of recent technology advances have occurred in reducing the hydrocarbon consumption, both as raw-material and fuel, in petrochemical processes.

34. The developing countries, as a rule, have depended mostly on foreign technology for the manufacture of petrochemical building blocks as well as conversion and down-stream facilities. However, this technology, conceived and implemented under alien conditions, and certainly not as a scape route from underdevelopment, does not necessarily correspond to the particular requirements and priorities of the developing countries. A fact which also renders its technical absorption and assimilation an onerous task. In some cases, the limitations on technological adaptability of these petrochemical processes, especially in the basics, are severe if at all existing. Furthermore the problem can be compounded by a lack of technical back-up from the licensors or contractors for the efficient, safe and on-spec. operation of the petrochemical plants under the general conditions of the developing countries. This also holds true even from the perspective of the construction, assembly and erection of the plants within battery limits, contributing to significantly higher capital expenditures in comparison with similar projects implemented in industrialized countries.

35. In the final analysis, construction cost escalations and operational inefficiencies are, inter alia, traceable to an absence of consideration, at R & D stage, of local parameters and their divergence from the industrial environment of the technology holder. The current low-level of technological capabilities of the developing countries greatly aggravate the encountered difficulties and perpetuates an unsatisfactory dependency on the industrial front in their economic development. The spin-off effects of petrochemical technology on other vital sectors of the economy such as agriculture, construction and, obviously, down-stream processing have been demonstrated to be substantial in the industrialized nations. In the developing countries, available evidence suggests that this multiplier effect can be even more powerful given the unrealized potential for absorption of petrochemical products in many sectors.

36. As argued previously, the bulk of available petrochemical technologies has been developed in a few industrialized countries by corporate entities in response to their policy assessment of a multitude of factors affecting the

industry. These factors, not all necessarily economic, will continue to determine the future orientation of technological change in the industry. This process of change by gathering both speed and scope at present, will entail profound repercussions beyond the traditional confines of the petrochemical industry.

37. Viewed from the perspective of the developing countries the foreign technology on offer invariably embodies some inherent incongruities and outlandishness in respect to:

- 1) optimal utilization of indigenous raw-material and energy resources;
- 2) capital cost structure of technology;
- 3) operational, maintenance and technical back-up characteristics;
- 4) responsiveness to local market potential;
- 5) socio-cultural acceptability and adaptability;
- 6) chain of technological continuity;
- 7) industrial and infrastuctural realities;
- 8) sectoral integration in the overall economy;
- 9) limitations of a genuine transfer of the know-how imbedded in technology; and
- 10) requirement of and impact on man-power training and development.

38. Although obtaining foreign technology for setting up petrochemical complexes in the developing countries has so far been the routine practice, it nevertheless has, on occasions, created innumerable problems of "mismatch". Realistically, the aquisition and transfer of overseas technology, in spite of its imperfections, has traditionally represented, the only mechanism for implementing the industrial aspirations of the developing countries. The cost of this process has, however, been unduly inflated by the technological unpreparedness of the recepients to accomodate its exigencies.

The root-causes of this insufficiency in technological capabilities are undoubtedly diverse, being subjected to expert scrutiny elsewhere in the petrochemical Consultations. Certainly a major force at play, must be the inadequacies of support from and the interaction with indigenous research and development capacity in the absorption and adaptation of foreign technology. The required assimilation cannot effectively take place in the absence of sufficiently developed technological capacities based on home-grown R & D efforts.

VIII. PETROCHEMICAL R & D OPTIONS FOR THE DEVELOPING COUNTRIES

39. Although the issue of research and development is of fundamental importance, as it plays an indispensable part in the creation of a sound basis of the petrochemical industry in the developing countries, nevertheless, intense impediments have precluded the formation of adequate technological capabilities. Meaningful research and development at the national level, obviously, necessitates mobilization of considerable resources, both in man-power allocation and in capital commitments, in turn, effective only in conjunction with well-entrenched scientific infrastructure and technical organization. The required number of highly-qualified scientists, engineers and managerial talents, backed with adequate facilities and equipment, is certainly, beyond the means of all but very few developing countries. Another essential ingredient is the linkage and the existence of appropriate channels for a continuous and substantive feedback between the research community and the operating petrochemical industries. This co-operation has proven exceedingly difficult, even in the industrialized countries, in cases where harnessing of research functions, outside corporate confines, is attempted. With the exception of a few developing countries public support for R & D in the petrochemicals has not been perceived as a high priority in industrial policies. Neither have technology adaptation concepts successfully counteracted the low levels of R & D productivity in these countries. In developing countries the role of government in the R & D sector is crucial, since many petrochemical companies simply cannot afford to possess state-of-the-art laboratories for analytical and technical services, pilot plants, testing etc.. In these cases the organization of back-up facilities and systems can only be state sponsored or even state-owned.

In order to gain a better appreciation of the magnitude of R & D efforts in a global context the indication of the following figures might be warranted.

For the first time spending for research and development in the United States will surpass 100 billion US \$ in 1985, representing 2.7% of the expected gross national product, a raise of 11% over the previous year. The chemical and allied products industry will have a 12% share of all industrial R & D expenditures in that country. Similarly other industrialized countries earmark a comparable portion of their aggregate income to R & D, whereas the corresponding budgets of most developing countries remain negligible not only in absolute terms but more adversely even in relation to the size of their national economies.

40) Aware of the pressing needs UNIDO has established a network of continuous petrochemical and polymer consultation-weeks in the field of R & D involving regional organizations and representatives of companies from developed countries to present papers on topical issues in that field. Such seminars have been held for example on man-made fibres in Bombay, India, in April 1982, for petrochemicals and polymers in Porto Alegre, Brazil, in May of the same year and for regional development of the petrochemical industry in Bahia Blanca, Argentina, in August, 1983; on plastic processing industries in Jubail, Saudi Arabia in October 1984 and one scheduled on synthetic fibres in China, for November 1985.

41. The recent advent of international long-term co-operation arrangements in the sector, notably petrochemical joint ventures, routinely incorporate provisions for research and development to be jointly undertaken by the partners. In actuality, however, the R & D work tends to be dictated by the foreign partners' own corporate strategies and conducted at his facilities with modest enhancement of the autonomous research capabilities of the host country's petrochemical entities. In view of these limitations inherent in a purely national approach to R & D in the petrochemical sector and the acknowledged shortcomings in the acquisition of foreign technology, common efforts on bilateral, regional or international basis represent a number of viable alternatives for the developing countries. The option of joint effort in research and development, hitherto largely untapped, can obviously assume a large spectrum of different modalities and operational mechanisms. These can range from co-sponsorship of specific technology ventures at established research facilities in the industrialized countries to the creation of regional technology clubs, co-ordinated technology import schemes, development consortia, consultative bodies or even "centres of excellence" with the participation of the world's leading technologists and scientists.

42. A prerequisite of this co-operation however, is a detailed assessment of the technological needs and priorities in the sector cast against a quantitative and qualitative analysis in respect to current involvement of the developing countries in petrochemical research and development work. Obviously, R & D initiatives at national level must reflect industry priorities with a view of translating them into a coherent and selective

framework. In view of the complexity of the subject and extremely high costs involved direct government subsidy and indirect schemes of fiscal and other incentives would be of particular importance for the success of such efforts.

43. The questions involved in formulating schemes for co-operation in this field are extremely varied, and so far little real attempt has been launched by the petrochemical fraternity or multilateral agencies to gain a better understanding of the complexities; prior to contemplating measures for partial solutions. Above all, the pooling of resources presupposes an in-depth understanding of R & D activities of the concerned countries in respect to manpower, facilities, equipment, programmes and projects. This could constitute a practical first step in the co-ordination effort, where UNIDO could conceivably play the pivotal role of a catalyst in this process of exchange of information and collective stock-taking. In the same context, a study could be launched to ascertain the scope and possible modalities of TCDC* in the field of petrochemical technology. The resource-rich developing countries, which have recently embarked upon large-scale petrochemical complexes with the accompanying massive transfer of know-how and technology are well-positioned to make substantive contributions to these efforts. It should be noted that a great deal of the R & D initiatives could be undertaken by the existing operational organizations through project co-ordination and particularly in many areas of down-stream product applications.

44. Likewise a number of Latin American and South-East Asian countries and a few others already possess considerable expertise in petrochemical technology enabling them to cater to many R & D needs of the less-exposed group among the developing countries. It is only through international co-operation that priorities in important areas of research and development in the petrochemical industry relevant to developing countries can be identified. At a second stage the experience so gained would then serve as a basis for concrete joint action to promote the development and diffusion of new petrochemical technologies among the developing countries.

* Technical co-operation between developing countries

IX. THE ISSUES

This paper has attempted to demonstrate the crucially important role of R & D and the resultant new technologies in the petrochemical industry. The costs, gestation time, and organizational resources involved in this process are so vast and varied that effective R & D targets are rendered beyond the possibilities of most companies operating in the developing countries, indeed beyond the collective capabilities of the countries themselves. In spite of these constraints, however some notable instances of successful R & D in few developing countries have recently been recorded. Viewed against a background where the mainstream of current R & D is undertaken in and directed towards conditions and needs of the industrialized countries it becomes imperative that special efforts be made in the developing countries to upgrade their autonomous involvement in this vital field. It stands to reason that co-operation in organizing this activity would make it less prohibitive by spreading its heavy burden over a number of countries. As argued previously co-operation could assume many forms and levels and UNIDO could contribute, on its part, to the promotion of such co-operative action. It is proposed that the following activities be considered as possible issues for further discussions and closer investigation on the subject by the Consultation:

1) - Establishment of regional R & D networks with special emphasis on:

- a. Exchange of information and creation of joint R & D activities on product application;
- b. Exchange of information and undertaking of joint initiatives in process development and/or improvement
- c. Exchange of experience and undertaking of co-ordinated schemes with respect to technology imports and technology transfer negotiations

- 2) - Surveys to assess the technological needs and priorities of developing countries in the petrochemical industry;
- 3) - Investigation into the feasibility of creating appropriate mechanisms such as regional technology clubs, development consortia, consultative bodies, centres of excellence etc.;
- 4) - Identification of opportunities for ECDC* in petrochemical technologies;
- 5) - The development of national policies, guidelines, blueprints for petrochemical research and development.

* Economic co-operation among developing countries



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THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY
IN DEVELOPING COUNTRIES

Issue Paper*

Prepared by the
UNIDO secretariat

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- I. BACKGROUND
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THE DEVELOPMENT OF PETROCHEMICAL INDUSTRY
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I. Background

1. The Second Consultation of the Petrochemical Industry, held in Istanbul, Turkey, 22-26 June 1981, recommended that UNIDO Secretariat: (a) examines the various forms of long-term arrangements for the development of the petrochemical industry in the developing countries and adapt the existing general guidelines on joint ventures; and (b), in co-operation with the parties concerned, develop a programme of co-operation among developing countries ^{1/}

2. The seminar on the petrochemical industry jointly organized by UNIDO, the Organization of Petroleum Exporting Countries (OPEC) and the OPEC Fund for International Development also emphasized the need to examine existing co-operation arrangements with a view to formulating guidelines for such co-operations. ^{2/} To this end an Advisory Panel of Experts formed by that seminar, convened three separate meetings. An additional meeting was organized between members of the Advisory Panel and representatives of the petrochemical industry in the developed countries. ^{3/}

3. The activities undertaken in pursuit of the recommendations pertaining to this issue have been divided and grouped under four different headings in this paper, namely:

a. world supply of and demand for petrochemicals;

b. survey and analysis of joint venture arrangements in the petrochemical industry;

^{1/} Report on Second Consultation on the Petrochemical Industry
ID/WG/7/Rev.1 para.3

^{2/} Report on OPEC/UNIDO/OPEC Fund Seminar on Co-operation among
Developing Countries in Petrochemical Industries, page 8

^{3/} Ibid, page 16

c. co-operation among developing countries to promote the development of the petrochemical industry; and

d. possibilities for global co-operation in petrochemicals

II. World supply and demand for petrochemicals

4. In order to collect accurate as well as independent information to enable inter-alia realistic projections for future supply of and demand for petrochemicals, a comprehensive data base has been compiled by UNIDO Secretariat. The first draft of this data base covers 25 major petrochemical products with a geographic coverage of some 110 countries in the form of statistical time series starting in 1970. This data base is subject to continuous expansion, revision and up-dating. It is currently structured on a country as well as on a product basis and will be incorporated in a computerized data management system.

5. The information contained in the data base has already proven indispensable in the preparation of various background, policy and issue papers in addition to providing valuable support for the purpose of project formulation in technical assistance activities. In a broader sense, the data base can be perceived as a valuable support of all work deployed with the objective of promoting the establishment of petrochemical industry in the developing countries.

6. The Expert Group meetings such as the Advisory Panel on Petrochemicals and Expert Group on International Co-operation in this sector, convened after the Second Consultation on the Petrochemical Industry to assist in implementing its recommendations, recognized the value and relevance of the data base and have emphasized the necessity of continuing this effort.

III. Survey and analysis of joint-venture arrangements in the petrochemical industry

7. In order to provide substantive and original inputs for the preparation of guidelines on joint ventures in the petrochemical industry, some 50 individual cases were studied. The objective of the survey, on the basis of case studies, was to adequately reflect the actual experience emanating from operating joint venture arrangements. The information thus obtained is treated as confidential, which although fully preserved in the guidelines nevertheless, convey the salient features of the joint ventures. The document contains a synopsis of views expressed by those responsible for existing joint ventures on a regional basis. The findings of the survey are represented in a matrix form, including the identification of a set of objectives, problem areas, role of government, conditions for success for joint ventures etc. The requirements for the creation of joint ventures in general, and for those between the developing countries in particular, are closely examined.

8. The basic methodology employed in drawing-up the guidelines rests on the potential of deducing meaningful conclusions from past experiences. This approach is also intended to enable a better understanding of the evolution of the joint venture concept in the petrochemical industry and its interaction with the current process of restructuring. Likely trends for future pattern of international joint ventures might equally be construed from the evaluation in respect to existing arrangements. The various components of joint venture agreements e.g. financing, technology, market, organization, feedstocks, infrastructure, planning, technical assistance, training, R and D and finally legal considerations have also been dealt with from the technical, commercial and corporate perspectives.

IV. Co-operation among developing countries to promote the development of the petrochemical industry

9. Accurate and reliable information is a basic prerequisite to all forms of co-operation between developing countries in the petrochemical industry. To this effect, a comprehensive information gathering and evaluation effort has been launched by the UNIDO Secretariat on three fronts:

- a. a data base on the supply and demand for 25 major petrochemical products starting with 1970 time series covering some 110 countries;
- b. a directory of technological capabilities of the developing countries in the petrochemical industry; and
- c. a survey of new process technologies having a direct bearing on the petrochemical industries of developing countries.

10. The second meeting of the Advisory Panel on Petrochemicals identified the opportunities for co-operation among developing countries. For this purpose, a system was designed where all individual elements inherent in this co-operation were identified. The Panel then focused its attention on the main factors and conditions for the successful contribution of that particular element to the overall and effective partnership among developing countries in promoting their petrochemical industries 4/.

11. In addition to the specific factors thus identified as influencing the opportunities for co-operation among developing countries in this industry, the Advisory Panel also considered the make-up of a general environment conducive to such arrangements. They underlined the importance of adequate channels of communication between the petrochemical entities of the developing countries, since information was judged crucial in fostering the desired co-operation.

4/ Report on Second Meeting of the Advisory Panel on Petrochemicals, Annex 2

12. The second area exerting an appreciable influence on co-operation concerns the need to undertake substantial efforts for confidence building and promoting mutual good-will among business partners. The reliability to honour commitments based on competence and experience has to be convincingly demonstrated.

13. Socio-economic stability and preparedness for continued co-operation in conjunction with an ability to adapt to evolving circumstances was considered another major element for successful business formations.

14. Finally, the availability of sufficient capital funds was recognized, as a precondition for initiating many joint activities among the developing countries in the petrochemical sector. The Panel concluded that, regrettably, sound business propositions, involving South-South co-operation, increasingly encounter difficulties in securing adequate packages from the established sources of funds.

V. Possibilities of global co-operation in petrochemicals

15. On the recommendation of the Second Consultation on the Petrochemical Industry, the first expert group meeting on international co-operation in this sector was convened by UNIDO, in Vienna from 19 to 21 September 1984.

The deliberations of the experts were organized around three main headings:

- a. opportunities opened by the global restructuring of the petrochemical industry
- b. basis for the promotion of international co-operation
- c. activities required to prepare and implement schemes of international co-operation

16. It was agreed among the experts that the difficult adjustment process facing the world petrochemical industry, necessitates, inter alia, close co-operation, up-to-date information systems, cross-sectoral coordination, realistic supply and demand projections, rational investment decisions, availability of technology, know-how and services, at global, regional and national levels.

17. This could be best achieved by elaborating package-type systems applied regionally. Education of both developed and developing countries to increase their awareness of global possibilities in the sector, would also greatly assist in harmonizing the global petrochemical operations in the utilization of available resources in a rational, economic and realistic manner.

18. The experts also concurred that government policies, especially in developing countries, provide an important framework for business evaluation and ultimately project profitability. Legislation pertaining to joint ventures, foreign investment, capital repatriation, fiscal incentives, tariff structure, pricing policy etc. are all crucial in attracting foreign participation in the petrochemical industry.

19. Up-to-date information about factors such as supply and demand, capacities, export and import potential, technology improvements, national policies, intersectoral linkages etc. were considered another indispensable basis for international co-operation and where UNIDO could play a leading role in the provision of such data.

20. UNIDO was equally requested to organize additional meetings of the responsible managers of the industry from both groups of countries in order to sensitize them to the many opportunities for international co-operation that exist but remain largely untapped. Exchange of experience was also felt in great need in promoting schemes of co-operation and in avoiding the creation of non-viable petrochemical projects.

21. One major impediment to the continued expansion of the sector in developing countries was, as expressed by a consensus, wide-spread inadequacies in market research and development. To remedy this situation would, apart from domestic implications, also remove a serious obstacle in the way of regional or international co-operation.

VI. The issues

22. Long-term arrangements for the development of the petrochemical industry in developing countries obviously encompass an extremely large and varied field of activities. The constituent elements corresponding to this umbrella-definition have been individually identified and discussed by three meetings of the Advisory Panel on Petrochemicals and the First Expert Group Meeting on international co-operation in this sector.

23. Two components, namely an analysis of joint venture arrangements and the creation of a petrochemical data base have been implemented by UNIDO secretariat, to be reported to the Consultation.

Additional work done by the secretariat and to be presented to the Consultation as background documents concerns:

- A global evaluation of the petrochemical industry and the new opportunities available in its future development;
- A comprehensive market analysis of the industry indicating trends with respect to trade and pricing policies, non-traditional forms of trade including buy-back and countertrade and their influence on the industry;
- A special study on the developmental and legal aspects involved in gaining access to technology improvements.

Among the other questions considered within the framework of long-term arrangements by the first expert group meeting, preliminary investigations relate to research and development in the industry and measures necessary to promote down-stream operations in the petrochemical industries of developing countries. These two questions are being presented as separate Issues to the Third Consultation on the Petrochemical Industry.

24. In addition, several important questions like financing, marketing, technology transfer, training, operational aspects etc. also warrant a closer scrutiny. In view of the limited resources at the disposal of the organization, a selective approach in tackling the more relevant aspects of problem areas inhibiting the development of the industry in developing countries is necessary.

25. To this effect, the Consultation is invited to consider some of these questions considered important which could be further developed by the UNIDO Secretariat. They could be grouped as follows:

- a. Activities related to the creation of a central data base on the petrochemical industry in UNIDO: data acquisition; organization of data, interaction with national and regional data centres, forms of data services, etc.
- b. Activities related to confidence building measures: Organization of workshops/seminars/meetings/training programmes, etc. to exchange experience in all fields related to the petrochemical industry, establishment of regional associations, technology clubs, etc.
- d. Activities related to in-depth analysis of opportunities for South/South co-operations in petrochemical industries such as regional survey of markets, resources, existing fora of industrial co-operation, availability of financing, etc.,
- e. Studies related to analysis/guidelines for government policies, facilities, programmes etc. conducive to the development of petrochemical industries and
- d. Activities related to gaining a better understanding of market development, marketing strategies, market services, market intelligence, etc.

The future development of petrochemical industry in developing countries will be facilitated by the progress achieved in these vital fields, which have been somewhat neglected in the past. Obviously the other activities of UNIDO aimed at the promotion of the industry will be continued.



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ISSUE NO.2

THE DEVELOPMENT OF DOWNSTREAM
PETROCHEMICAL INDUSTRIES IN DEVELOPING COUNTRIES

Issue Paper*

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I. BACKGROUND

The Second Consultation on the Petrochemical Industry, held in Istanbul, Turkey from 22 to 26 June 1981, discussed the issue of "Opportunities for co-operation between industrialized and oil- and gas-producing developing countries for the development of downstream petrochemical industries in other developing countries" and recommended UNIDO to take further action for future consideration.^{1/}

The Third Meeting of the Advisory Panel on Petrochemicals, convened in Vienna, Austria, from 3 to 5 June 1985, discussed the requirements, contributions and difficulties that might be faced in the development of downstream industries in developing countries and recommended UNIDO to carry out a study on the main forces governing the development of these industries on project, national and regional levels, in order to help developing countries optimize their resources, giving special emphasis to countries which are currently embarking on the establishment of such industries.

To this end, UNIDO has established a network of continuous seminars (consultation-weeks) on downstream petrochemical industries in developing countries, involving regional organizations and companies from developed countries, to expose and discuss topical issues in this field. Such seminars have been held, for example, on man-made fibres in Bombay, India, in April 1982; on polymers and petrochemicals in Porto Alegre, Brazil, in May of the same year and in Saudi Arabia in October 1984. One seminar on synthetic fibres is scheduled in Beijing, China, for November 1985, and another on plastics in agriculture in Alexandria, Egypt, for December 1985.

^{1/} ID/WG.336/71/Rev.1

II. INTRODUCTION

World demand for plastics, fibres and rubbers is estimated in 1985 at 70 million tons, representing a value of production, as final technical goods, surpassing 100,000 million US dollars. Recently, the industry has grown at a relatively slower pace compared with earlier years as shown in table 1. While the demand for synthetic rubbers has contracted lately, some segments like engineering resins have witnessed impressive growth rates averaging around 30% in 1984.

Table 1

Demand for the main plastics, rubbers and fibres
(1000 metric tons)

	1970	1975	1980	1984	Average annual growth rate (%)		
					1970-75	1975-80	1980-84
PVC	6200	7800	11600	13300	5,2	9,7	3,7
LDPE ^{2/}	5700	7400	11200	13600	6,0	10,3	5,4
HDPE	2000	2900	5700	7500	9,0	19,3	7,9
PP	1700	2700	4750	7100	11,8	15,2	12,4
PS	2200	3900	4800	5900	15,5	4,6	5,7
 Total Plastics	 17800	 24700	 38050	 47400	 7,8	 10,8	 6,1
 Rubbers	 6400	 7600	 8800	 8300	 3,75	 3,2	 -1,4
Fibres ^{3/}	2600	5000	6000	6700	18,5	4,0	2,9
 Total Downstream	 26800	 37300	 52850	 62400	 7,8	 8,3	 4,5

Source: UNIDO Data Base

^{2/} including LLDPE

^{3/} yarn not included

Last year, however, demand for plastics registered a vigorous rebound since the recent recession which hit bottom in 1982. Compared with other industrial sectors, the downstream petrochemical industries have performed better during the last ten years, notwithstanding the effect of major oil price increases.

During the 5 year period 1982 - 1987 the global growth in demand for commodity plastics is expected to be 4,5 per cent. However, this growth is expected to be more pronounced in developing countries, about 6-9 per cent yearly, and less in developed countries, about 2,5 per cent in Europe, and 4,4 per cent in the USA.

Considering the basic segments of the downstream petrochemical industries, plastics have achieved the best performance, followed by fibres and then rubbers which have recently suffered from stagnating, or even shrinking, demand. In developed countries, rubbers fared better than fibres, whereas in developing countries both grew at a healthy rate.

Recent technological advances in polymerization techniques, raw material and product compositions, process development etc., have given new vigour to the process of substitution of traditional products, especially in plastics and to a lesser extent in rubbers and fibres. The properties of some of the new products are clearly superior to those of traditional products, such as steel. This development has opened a growing potential of the new technologies for innovative applications.

A gradual shift from commodity products to specialties characterizes the current development trend in petrochemicals in developed countries, which is backed up by substantive R and D efforts. Expenditure in R and D has now reached 15 per cent of the value of total sales in most companies. An inevitable consequence of the current efforts in commercializing new technologies is the intense degree of integration on a global level, not only in upstream but also in downstream petrochemical industries, including medium or small scale entities.

III. DOWNSTREAM PETROCHEMICAL INDUSTRIES

Customarily, the processing industries of the product groups of plastics, rubbers and fibres, constitute the downstream petrochemical industry. However, there are a number of different, polymerized or non-polymer product groups, various additives, detergents, inhibitors, accelerators, surface active agents, coagulators, paints etc., constituting perhaps over a hundred different chemical groups, called specialty petrochemicals, which are often included in the downstream petrochemical industries.

The composition of the downstream industries varies tremendously between countries and regions. However, virtually every country has established some of these industries, including the least developed countries. The technologically more advanced developing countries like Brazil, Mexico, the Republic of Korea etc. have established a full range of these industries in thousands of operating companies and plants. For instance, in India, there are more than 10,000 plastic processing companies, as compared to only a very few in some African countries. Considering the extremely low per-capita consumption of the products of these industries at present, there is a large potential for their growth in all developing countries. Many areas of application of these industries in the developing countries are considered to be lagging far behind the state-of-the-art industries. The impact of down-stream operations on the development of the industrial sector in general and other sectors of the economy, such as agriculture, construction, transport, the services sector, etc. is such that their development becomes a contributing factor to the overall growth of the economies of the developing countries.

IV. CHARACTERISTICS OF THE DOWNSTREAM PETROCHEMICAL INDUSTRIES

Plastics, fibres and rubbers processing industries, constitute about 75 per cent of total production of downstream petrochemical industries. Plastics are the more prominent group with their versatile uses in countless consumer goods, as well as their ever-increasing penetration in industrial applications where they are commonly referred to as engineering plastics. Generally, downstream petrochemical industries are highly service-oriented industries needing close contact with customers to attend to their specific technical requirements in respect to both production and application.

PLASTICS

Plastics are the most versatile group of all downstream petrochemical industries and as such are characterized by generating a continuous flow of new products and applications. The polymers involved in plastics embrace polyvinylchloride (PVC), polyethylenes (low density LDPE, linear low density LLDPE and high density HDPE), polypropylenes (PP) and polystyrene (PS) as main constituents. Together they form a group which is commonly known as commodity plastics. An impressive new group known as engineering plastics has emerged to fulfil a variety of engineering needs. These are basically composed of hard polymers such as polypropylenes, nylons, polycarbonates, polyphenylenes, acetals, thermoplastic polyesters, polysulfones, polyphenylene sulphides of special grades reinforced with glass fibres, aramid fibres, carbon fibres etc. The application field of this group of products is currently expanding at a fast pace; for example, their average use in motor vehicles has increased from 54,8 kg in 1980 to 74,2 kg per unit this year and is expected to reach some 105 kg by 1990.^{4/}

The techniques, commonly used in plastics processing, include extrusion, coating, injection moulding, reaction injection moulding, blow moulding, calendering, thermo-forming and pultrusion and their variations. With these techniques, a variety of products ranging from those commonly used in consumer goods of everyday life, such as cups, bags, toys etc., to industrial products like large-diameter pipes or boats can be produced.

^{4/} Engineering, May 1984

Some of the main factors contributing to the continuously increasing demand for plastics and their growing potential for substitution of traditional materials are:

- 1) need for lighter products to save energy;
- 2) need for easier-to-handle products to save manpower and costs;
- 3) need for easier-to-form products to save machine and manpower hours;
- 4) need for more competitive products calculated on cost/performance basis;
- 5) need for more corrosion resistant, better surfaced products to save in maintenance and capital cost;
- 6) need for stronger products in rigorous applications;
- 7) need for new systems and technologies to cater to innovative engineering applications;
- 8) need for cost-effective systems in sectors, like agriculture, utilities, distribution etc.;
- 9) need for better and competitive technologies to improve global market sharing; and
- 10) need for new and better products to improve living conditions.

These needs explain, to a large extent, the growth in demand for commodity plastics surpassing GDP growth rates, despite heavy restructuring in the upstream petrochemicals and the oversupply situation that has persisted in recent years.

RUBBERS

Synthetic rubbers often in combination with natural rubber, are predominantly used for industrial purposes such as manufacture of conveyer belts and vessel linings and car and truck tyres, with the latter accounting for the bulk of demand. After a steady growth from 1956 to 1973, at an annual rate of 9,7 per cent, consumption of synthetic rubbers suffered a set-back which amounted to a 4% reduction in 1974 and 23% in 1975 from the 1973 peak 5/.

The advent of radial tyres and other improvements have dramatically increased the average tyre life, thus reducing demand for natural and especially synthetic rubber. The increase in the price of synthetic rubber due to higher costs of feedstocks and energy have also rendered natural rubber more competitive. However, the outlook for synthetic rubber is improving due to some revival in demand, as can be seen from Table 2.

Table 2

Rubber consumption in market economies (thousand tons)

	1982	1983	1984	1985*	1988*	1989*
SBR	2544	2648	2768	2824	2943	3079
Polybutadiene	813	855	969	991	978	1102
Ethylene-Propylene	308	343	408	426	416	496
Polychloroprene	231	241	250	254	259	269
Nitrile	162	167	193	198	196	218
Other	757	740	813	843	828	949
Total Synthetic	4815	4994	5401	5536	5630	6113

Synthetic as % of total

rubber consumption 61.8 61.6 62.0 62.1 61.9 62.3

* estimates

The most commonly used synthetic rubbers are styrene butadiene rubber (SBR), polybutadiene rubber (PB), ethylene-propylene rubber (EPR), butyl rubber (BR), nitrile rubber (NR), isoprene and chloroprene.

FIBRES

The most commonly used synthetic fibres are polyester, polyamide and acrylic fibres. However, new entrants such as polypropylene fibres have swiftly increased their share during the 1980's.

Production of synthetics fibres accounted for 70% of the total man-made fibre production in 1984 ^{6/}, a year which registered a record level of production in synthetic fibre, which amounted to 12 million tons, up 1.3 million tons or 12.5% over the production figure of 1980.

The synthetic fibres sector was the first to suffer from oversupply in the early seventies. It is also the only sector where an attempt was made to negotiate a global co-operative restructuring through the mechanism of the Multi-Fibre Agreement (MFA), which governs the major part of world's trade in textiles and clothing. The arrangement was first entered into in 1974 and was later renewed in 1978 and 1982 and is due to expire in 1986. Its continuation is currently being negotiated.

^{6/} Chemical and Engineering News, March 1985

V. RELATIONSHIP BETWEEN THE NATIONAL ECONOMY AND DOWNSTREAM PETROCHEMICAL INDUSTRIES

Downstream petrochemical processing industries supply materials to about all economic sectors and are widely used to provide essential inputs for those related to water management, utilities, information networks, transportation facilities, housing, construction, clothing, packaging, health care, storage etc. The products cover some of the basic needs of the population and provide indispensable materials and equipments.

Although no exact statistics can be quoted to quantify the impact of this industry on the general performance of the economy, some important qualitative factors maybe mentioned for illustrative purposes:

- 1) The processing of basic, intermediate and polymer production is often carried out by small-scale production units which employ a large number of people;
- 2) The value added through processing, greatly contributes to the improvement of the economy of the country;
- 3) The numerous products of this industry and the replacement of imported traditional materials at high cost, improve the balance of payment of the economy;
- 4) The impact of these products on the performance of other productive and service sectors and the general welfare of the population is appreciable;
- 5) Greater economic savings are made possible by this industry, through less corrosion, better maintenance, and improvements in infrastructure;
- 6) Availability of the products of these industries can vitalize other economic sectors; agriculture, utilities, construction and the general economy;

- 7) Due to the research intensiveness of this industry, there is a positive impact on improving of the technological infrastructure of the country; and
- 8) Genuine acquisition and mastery of technology embodied in these industries can have a synergistic effect on many other industries and thus on the national economy in general.

VI INTEGRATION OF THE DOWNSTREAM PROCESSING INDUSTRIES

Traditionally, the petrochemical industry in many developing countries starts with the establishment of downstream processing industry in the field of plastics, fibres and rubbers. This is not surprising, since the requirements of processing plants can be relatively modest with regard both to capital deployment and skilled manpower. Moreover, the establishment of this industry is further encouraged by the replacement of imported and costly traditional products and materials. In many cases foreign companies, producers of polymers, participate, through joint ventures or other mechanisms, in establishing those industries in the developing countries in order to expand their marketing activities.

In view of the above, the development of the petrochemical industries often takes shape under conditions not necessarily compatible with the needs and socio-economic priorities of the developing countries. When the economies of these countries develop further, it then becomes difficult to readjust the initially imposed constraints in the establishment of this industry, characterized by fragmented development, to the process of resource optimization through backward and/or forward integration in the economy. Since the petrochemical processing industry dictates the type and pattern of demand for polymers, which, in turn, determine the type of intermediate and basic petrochemicals needed for their production, the processing industry becomes the most vital link in the chain of integrated development of the petrochemical industry.

It is thus imperative for developing countries, aspiring to produce bulk petrochemicals to streamline the progressive path of developing their downstream processing industries in order to create the necessary market conditions needed to absorb commodity petrochemicals. This streamlining can obviously transcend their national boundaries to neighbouring developing countries, in order to create, on co-operative basis, the necessary market outlet that could absorb the production of a world scale production unit.

The occurrence of market fragmentation, based on marginal differentiation in the characteristics of commodity products, which is becoming increasingly prevalent in the developed countries, could greatly undermine the future integration of downstream petrochemical processing industry in developing countries with the production of basic, intermediate and finished petrochemical products. This process should always be viewed within the context of the real development needs of developing countries.

VII. IMPACT OF TECHNOLOGICAL INNOVATION ON DOWNSTREAM PETROCHEMICAL PROCESSING INDUSTRIES

Numerous technological innovations applied to the downstream processing industries have led to improved new products and applications. Better and stronger polymers have enabled considerable downsizing of final product thicknesses in films and pipe-walls at lower costs, increasing the competitiveness of plastics applications. In production facilities, the invention of co-extrusion, to join two or more base plastics, has introduced tremendous versatility to adjust product specification and to prepare customer-oriented products for specific application.

Composite materials are increasingly contributing to the creation of improved additives, fillers, stabilizers, smoke depressants etc. Changes in the processing facilities, like tools, moulds etc., are another expression of technology refinements.

The numerous innovations applied in plastics have their counterparts in the rubber technology. Major improvement in tyres manufacturing have been mainly directed towards improved radial tyres, better tread, ozone resistance etc., which will eventually increase the average tyre life to 100,000 miles. The average weight of a passenger car tyre has already been reduced from 13 kg in 1973 to 9,8 kg in 1983. At the same time, rubbers, such as ethylene-propylene-diene monomer have increased the non-tyre uses.

No breakthroughs in fibre technology has been recorded recently, although some innovations are in the pipe-line. The main synthetic fibres; polyesters, polyamides and acrylics, have held their position. However, they are subject to similar innovative changes as those occurring in plastics to satisfy consumer preferences for natural feel and breathability. Already, polyesters imitate silk and wools, nylons have gained the feel of cotton by blending nylon-6 and polydioxo-amide. Also such new entrants such as 4,6-nylon, high strength polyethylene fibres, composite fibres, etc. might hasten the traditionally stable and uneventful development of the fibre sector.

It should be indicated that these innovations have not had an adverse impact on the demand of the conventional volume plastics. These volume plastics will maintain their position of dominance in the market place for a long time, particularly in developing countries.

VIII. PROBLEMS LINKED TO DOWNSTREAM PETROCHEMICAL INDUSTRIES IN DEVELOPING COUNTRIES

Contrary to the highly concentrated nature of the upstream basic, intermediate and finished petrochemicals, the downstream industry processing those products are generally fragmented, small scale and often require only limited financing.

The small or middle sized entrepreneur plays a crucial role in the development of this industry. A number of end uses are often developed on the basis of ideas and experiences of technically-oriented people, who with modest funds, proceed with implementation. However, this can lead to a haphazard development of this industry, unless it is carefully monitored and organized. In spite of the apparent simplicity in the establishment of plants there are a number of problems which have to be solved. The main difficulty of this industry is the sophistication and fast changing nature of its technology. It requires user oriented information which is technically complicated and not readily available. Without this information it is difficult to produce durable products and enhance their acceptability to customers. Consequently, it is often hard to find entrepreneurs who accept the risks involved without proper incentive schemes.

Moreover, these industries require appropriate back-up on a continuous basis in the field of the production as well as for market research, distribution and marketing. The mere existence of a product and the demand for it does not automatically guarantee its sale and application, without extra marketing and after-sales services efforts.

Thus to ensure the viability of these projects, specialized training at different sectoral and product levels is needed to sustain successful development in the burgeoning plants, prior to start-up and for a long time thereafter.

IX. SUCCESSFUL SOLUTIONS TO THE DEVELOPMENT OF DOWNSTREAM PETROCHEMICAL INDUSTRIES

The various general advantages arising from downstream petrochemical processing industries have been mentioned earlier. It is, however, essential to study the case of each country on its merits, paying special attention to the size of its markets, availability of feedstocks, stage of economic and social development, national priorities, availability of natural resources, and other pertinent factors. A detailed analysis of development indicators, relevant to these processing industries and the end-use sectors such as water management (including drinking water, irrigation, waste water, water storage) packaging and storage of foods, agricultural uses, transportation, construction of houses and factories, health care, household products, textiles etc., should be evaluated in order to define the market size, possible share and future potential of each segment of this industrial sub-sector.

The public sector, through central statistical offices and other similar institutions, could play a crucial role in collecting market information, import/export statistics at product level, which provide the necessary background to help develop these industries according to the market needs and potential demand for the products of this industry. The involvement of institutions, research centres, academia, "centres of excellence", associations etc., in studying, collecting and dissemination technical, legal and financial information on this subject could greatly help these industries, especially at their incipient stages.

Since entrepreneurs play a significant role in this area, suitable incentives could be provided by governments to help them in the construction and successful operation of their plants. Government-sponsored training and education schemes become an essential element for the success of these industries.

Bearing in mind the complexities of these industries and need to adapt them to the environment of developing countries, extensive co-operation, at company and country levels on both South/South and North/South levels, would be needed. Such co-operation would be most useful in the areas of processing needs, product quality control and other related technical parameters. One important factor which has always to be borne in mind when contemplating this industry, is the extent of its potential backward integration in the petrochemical industry and how effective it will be in influencing the development of other sectors of the economy.

X. THE ISSUES

Downstream processing industries in developing countries cover a vast number of products, production lines and applications spanning the full spectrum of operating companies, whose intermediate materials are overwhelmingly supplied from developed countries. Such dependency offers little, if any, possibilities for the development of autonomous technologies. Resource endowment, unsaturated and expanding markets and basic necessities all would warrant an accelerated growth of these industries in the developing countries. Viewed against this background, it becomes imperative that special effort should be made by the developing countries to upgrade their involvement in this vital sector. Co-operation in organizing and co-ordinating these activities would increase their benefit and spread their costs over the number of participating companies/countries. UNIDO could, for its part, contribute to such co-operation. It is proposed that the following activities be considered by the Consultation as possible issues for closer investigation and follow up action:

- 1) Survey and analysis of downstream petrochemical industries in developing countries with a view to fostering regional co-operation;
- 2) Based on the above-mentioned survey and directed towards the promotion of co-operation between developed and developing countries and among developing countries, preparation of a directory of capabilities existing in the area of downstream processing industries in developing countries;
- 3) Drawing-up guidelines on national policies for the promotion of downstream petrochemical processing industries; and
- 4) The establishment of a programme/scheme of active ECDC and North/South co-operation in downstream petrochemical processing industry.